

**COOLING DEVICE FOR ELECTRICAL POWER UNITS OF
 ELECTRICALLY OPERATED VEHICLES**

[0001] The invention relates to a cooling device for electrical power units of electrically operated vehicles as claimed in patent claim 1.

[0002] It is generally known to equip vehicles with electrical traction drives. DE 37 28 171 C2 discloses, for example, an electromechanical drive system for a full-track vehicle. At least one electric traction motor and an electric steering motor are provided and can be used to mechanically transmit the regenerative steering power from one drive side to the other.

[0003] EP 1 060 941 B1 discloses a device for controlling and operating an electrical vehicle drive. In this drive arrangement, each drive side is provided with its own electric drive motor.

[0004] In order to supply electrical power to the electric motors for driving such vehicles, current generators - which are driven by internal combustion engines - are generally provided. The electrical power is transmitted to the electric motors via corresponding power units. Such power units comprise a power section and a control section which are combined to form a compact physical unit. Depending on the transmitted power, the power units heat up and have to be cooled in order to protect their components from overheating. Powers which are transmitted in the power sections are 1 to 4 powers of ten (10 to 10^4) greater than in the control sections.

[0005] The single loop cooling systems used have to be designed for the lower maximum permissible temperatures of the control electronics. Therefore, large heat exchangers containing correspondingly large amounts of coolant are required in order to be able to dissipate

the large amount of heat which is produced in the power sections using the low cooling power of such a low temperature cooling arrangement.

[0006] On this basis, the object of the invention is to provide a cooling system which can be used to sufficiently cool both the control section and the power section and which makes it possible to use smaller heat exchangers.

[0007] According to the invention, this object is achieved by the characterizing features of patent claim 1.

[0008] It is advantageously possible to use smaller heat exchangers by dividing the cooling system into a low-power, low temperature cooling circuit for the control electronics and a high power, high temperature cooling circuit for power electronics, as suggested by the invention.

[0009] The cooling system according to the invention is particularly advantageous for electrically operated vehicles since it contributes to reducing the overall weight of the drive system.

[0010] Further features and advantages can be found in the subclaims in conjunction with the description.

[0011] The invention is explained in greater detail below with reference to the associated schematic drawing, in which

[0012] Fig. 1 shows a block diagram of a cooling device according to the invention.

[0013] Fig. 1 illustrates an electrical power unit 1 for supplying power to an electric motor for an electrically operated vehicle. Since the present

invention relates to cooling such a power unit 1, the electrical cabling to an energy source and the associated electric motor, and the signal lines between operator control devices of the vehicle, such as the accelerator pedal, steering device and the like, and the power unit 1 are not illustrated.

[0014] The power unit 1 which is illustrated by way of example is arranged on a printed circuit board 4 in a housing 5. The power unit 1 which, in a known manner, comprises a control section 2 and a power section 3 is preferably arranged on the printed circuit board 4 in such a way that the electronic components which belong to the control section 2 and the power section 3 take up a respective region on the printed circuit board 4.

[0015] A first cooling circuit 11 containing a heat exchanger 9 is provided for the control section 2 and a further cooling circuit 12 containing a heat exchanger 10 is provided for the power section 3. The heat exchangers 9, 10 are designed for extreme ambient conditions with ambient temperatures of approximately 50 degrees Celsius. On this basis, the heat exchanger 9 can be designed in such a way that a feed temperature of approximately 70 degrees Celsius is provided for the more sensitive components of the control section 2.

[0016] A higher feed temperature of approximately 90 degrees Celsius is permissible for the power section 3 which converts a multiple of the power converted by the control section 2. On account of the physical relationship in which the flow of heat is proportional to the product of the volumetric flow and the temperature difference of the coolant, the heat exchanger 10 with the higher temperature has a greater cooling power. The heat exchanger 10 can therefore be designed to be smaller than a heat exchanger with a lower temperature, while maintaining the cooling power.

[0017] On account of the higher cooling power of the second heat exchanger 10 for the power section 3 and the amount of heat which is small in relation to the power section and has to be conducted away from the control section 2, the two heat exchangers 9, 10 together are physically smaller than an individual heat exchanger which would have to cool both sections of the power unit at the lower temperature.

[0018] The two heat exchangers 9, 10 are preferably arranged in series and a fan 13 can additionally be provided in order to back up the cooling power.

[0019] It is particularly advantageous to provide partition walls 6, 7 between the power section 3 and the control section 2, these partition walls extending as far as the common printed circuit board 4 and dividing the housing 5 into two regions which are closed off from one another. The partition walls 6, 7 are preferably produced from a thermally insulating material.

[0020] Cooling ducts 8, 14 for conducting the coolant can be provided in the housing 5 and on the partition walls 6, 7 for the different cooling circuits 11, 12.

[0021] Instead of producing the power unit 1 as a compact assembly, it is also feasible for the power section 3 and the control section 2 to be arranged such that they are physically separate from one another.

[0022] In general, the components of the power section generate a large amount of waste heat but can also withstand high ambient temperatures, whereas the components of the control section generate less waste heat but can only withstand a lower ambient temperature. In the case of exceptions from this rule, it is also entirely possible to place elements which are typical of the power section in the region of the

control section if these generate a small amount of waste heat or only withstand relatively low ambient temperatures. It is equally possible to place components which are typical of the control section in the power section if these withstand high ambient temperatures. It may also be advantageous to break up the independent assemblies of the power section and the control section as such, and form new assemblies whose elements are combined according to generation of and sensitivity to heat.

[0023] The important core feature of the invention can be seen in providing two separate cooling circuits for cooling an electrical power unit of electrically operated vehicles, and cooling the components of the power section which are subject to a higher temperature using a more powerful high temperature cooling circuit. On account of the improved cooling power of the high temperature cooling circuit, a more compact heat exchanger can be provided for the significantly larger amount of heat which mainly has to be dissipated from the power section. A relatively small heat exchanger with a lower coolant temperature can also be provided for the relatively small amounts of heat from the control section. The overall result is therefore an advantageous reduction in the size of the cooling system compared to a single heat exchanger which has to cool both the power section and the control section with a low temperature.

[0024] The reduction in size of the cooling system results in smaller heat exchange areas and smaller amounts of coolant.

[0025] **List of reference symbols**

- 1 Power unit
- 2 Control section
- 3 Power section
- 4 Printed circuit board
- 5 Housing
- 6 Partition wall
- 7 Partition wall
- 8 Cooling duct
- 9 Heat exchanger
- 10 Heat exchanger
- 11 Cooling circuit
- 12 Cooling circuit
- 13 Fan
- 14 Cooling duct